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(Reaffirmed 2002)

Indian Standard

CODE OF SAFETY FOR BENZENE, TOLUENE AND XYLENE

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Indian Standard
CODE OF SAFETY FOR BENZENE, TOLUENE AND XYLENE

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Indian Standard
CODE OF SAFETY FOR BENZENE, TOLUENE AND XYLENE

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 12 March 1968, after the draft finalized by the Chemical Hazards Sectional Committee had been approved by the Chemical Division Council.

0.2 Benzene, toluene and xylene are used as raw materials in the manufacture of synthetic chemicals, dyes, paints, medicines, explosives, and as solvents. Benzene, toluene and xylene are liable to cause various types of hazards due to their toxicity, flammability and explosiveness. Regular or systematic procedures for inspection to ensure safeguards against the hazards involved are, therefore, necessary.

0.3 Benzene, toluene and xylene are deemed as highly flammable and explosive materials, within the meaning of the Indian Explosives Act, 1884 and Rules framed thereunder. Their filling, possession, storage, transport, etc, are governed by the Petroleum Act, 1934 and Rules framed thereunder with any alterations and additions made thereafter.

0.4 In the preparation of this code of safety considerable assistance has been derived from the following publications:

PIETERS (H A J) and CREYGHTON (J W). Safety in the chemical laboratory. 1957. Ed. 2. Butterworth Scientific Publications, London.

Z 37.4-1960, Z 37.10-1960 and Z 37.12-1960 Maximal acceptable concentration of benzene, xylene and toluene respectively. American Standards Association, USA.

Chemical safety data sheets No. SD-2 for benzene and No. SD-63 for toluene. Manufacturing Chemists' Association, USA.

IRVING SAX. Dangerous properties of industrial materials. 1957. Reinhold Publishing Corporation, New York, USA.

1. SCOPE

1.1 This standard prescribes a code of safety for benzene, toluene and xylene. It describes the properties and essential information for their safe handling and use.

2. TERMINOLOGY

2.1 For the purpose of this standard, the definitions given in IS : 4155-1966* shall apply.

3. PROPERTIES OF BENZENE, TOLUENE AND XYLENE

3.1 Some of the important physical properties of benzene, toluene and xylene are described in Table 1.

TABLE 1 PHYSICAL PROPERTIES

Sl No.	Characteristic	Benzene	Toluene	Xylene		
				Ortho	Meta	Para
(1)	(2)	(3)	(4)	(5)	(6)	(7)
i)	Colour	Water White	Water White	—	—	—
ii)	Odour	Aromatic	Aromatic, Benzene like	—	—	—
iii)	Vapour density (air = 1)	2·70	3·14	3·66	3·66	3·66
iv)	Flash point, °C (closed cup)	—11·1	4·4	17·2	25	25
v)	Ignition temperature, °C	538	552	495·5	—	—
vi)	Explosive limits (percent by volume) in air	1·5-8	1·27-7·0	1·0-6·0	1·1-7·0	1·1-7·0
vii)	Boiling point, °C at 760 mm Hg	80·1	110·6	143·6	139·0	138·3
viii)	Melting point, °C	5·5	—95	—25·3	47·9	13·2
ix)	Relative density 20 /4°	0·879	0·866	0·880	0·864	0·861
	Relative density 27 /27°	0·875	0·863	—	—	—

4. HAZARDS ASSOCIATED WITH BENZENE, TOLUENE AND XYLENE

4.0 General — It should be remembered that in case, benzene, toluene or xylene vapour is mixed with other inorganic or organic vapours, hazards do not minimize.

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*Glossary of terms relating to chemical and radiation hazards and hazardous chemicals.

4.1 Benzene

4.1.1 *Health Hazards* — The principal hazard is from inhalation of the vapours of benzene. Acute poisoning results from inhalation of high concentrations of vapour (above 3 000 ppm by volume in air) usually for short periods of time, often a matter of minutes. Chronic poisoning results from daily exposure to unsafe concentrations of benzene vapour over a prolonged period of time. The threshold limit value of 25 ppm has been set by some groups, at present, for benzene. It is also a mild skin irritant.

4.1.1.1 *Acute toxicity*

a) *Systemic effects* — Breathing of high concentrations of benzene vapour may cause acute poisoning. A concentration of 3 000 ppm in the air may cause no symptoms even up to an hour's exposure. The danger increases until at 20 000 ppm death may follow after 5 or 10 minutes' exposure. Early symptoms may include dizziness, headache, breathlessness and excitement. These may be followed by mental confusion and hysterical symptoms, such as laughter, shouting, cursing and singing, generally with marked obstinacy. This stage is often called the 'benzene jag'. In extreme cases, it may be followed by collapse, unconsciousness and death. The effects of acute exposure are essentially anesthetic and upon recovery from a single exposure, it is most unlikely that there would follow any such changes as are noted in chronic poisoning, such as injury to the blood forming system. Cases of injury due to swallowing benzene are rare. This is usually accidental and may cause burning abdominal pain, vomiting, staggering gait, drowsiness and unconsciousness. It may later cause bronchitis or pneumonia probably from some benzene entering the air passages.

b) *Local effects* — The liquid is a mild skin irritant.

4.1.1.2 *Chronic toxicity*

a) *Systemic effects* — Chronic poisoning results from repeated exposures to unsafe concentrations of benzene vapours (more than 25 ppm by volume in air) over a prolonged period (weeks or months). This results in weakness and anemia (reduction in the number of red blood cells and other blood constituents) due to the effect on the blood-forming organs. These symptoms may occur some time after cessation of exposure.

b) *Local effects* — Prolonged and repeated contact of liquid benzene with the skin cause a defatting action with resulting drying out of the skin and dermatitis.

4.1.2 *Fire and Explosion Hazards* — Benzene is a highly flammable liquid and its vapours form explosive mixtures with air (*see* Table 1).

4.2 Toluene

4.2.1 *Health Hazards* — Toluene is not a highly toxic chemical; however, under certain circumstances, it may be hazardous and measures to minimize exposures are necessary. Toluene is readily absorbed by the gastro-intestinal tract, the lungs, and to a small extent, through the intact skin. Part of the absorbed toluene is eliminated in the expired air, but a large percentage is excreted in the urine. The only industrial hazards of significance result from inhalation of excessive concentrations of the vapour, prolonged skin contact with the liquid, and liquid contamination of the eyes. In high vapour concentrations, such as may be encountered in tanks or partially-closed vessels, toluene exerts a powerful narcotic action. Under these conditions and with sustained exposure, death may ensue from paralysis of the respiratory centres. Vapours in subnarcotic concentrations, but in excess of the threshold limit value (200 ppm), produce varying but usually transitory manifestations of central nervous system disturbance. The liquid, when splashed into the eyes, may produce opacities and corneal burns unless it is removed promptly. Dermatitis is produced only after repeated or sustained contact with the liquid. Common objective responses, such as recognition of odour and irritation of the eyes and nose, cannot be relied upon as warning signs of excessive exposure. Olfactory fatigue and tolerance occurs early and conditioned operators usually do not perceive the odour or mildly irritative processes. The simple effects on the central nervous system, such as persistent headache, giddiness or undue fatigue are, however, useful criteria for the identification of concentrations of toluene in excess of safe limits for prolonged periods of exposure.

4.2.1.1 *Acute toxicity*

a) *Systemic effects* — Toxic manifestations resulting from a single exposure will vary with the atmospheric concentration of toluene encountered and the duration of exposure. Acute exposures of short duration and at infrequent intervals may be tolerated without irreversible damage. However, sustained exposure to concentrations of toluene which produce narcosis may result in fatal in paralysis of the respiratory centres.

b) *Local effects* — Contact of the skin liquid toluene will often result in a temporary burning stinging sensation. Occasional accidental contamination of the skin with the liquid presents no serious hazard if the affected areas are washed promptly with soap and water until free of toluene. Contact of the eyes with liquid toluene results in burns of varying degrees of severity. Immediate flushing of exposed eyes with copious quantities of water for 15 minutes minimizes the possibility of serious injury.

4.2.1.2 *Chronic toxicity*

a) *Systemic effects* — Continuous daily exposures to concentrations of toluene vapours in excess of 200 ppm may give rise to a clinical picture of chronic toluene intoxication. Such cases may show varying degrees of fatigue, general nervousness, insomnia, and loss of appetite and weight. However, upon complete cessation of exposure — which is indicated — such individuals, usually, soon regain their normal levels of health.

b) *Local effects* — Frequent or sustained skin contact with liquid toluene may result in the development of dermatitis because of the defatting properties of toluene as well as its local irritative action. Protective creams are not a substitute for avoidance of excessive skin contact by other means.

c) *Sensitization* — Sensitization to liquid toluene is not known to occur.

4.2.2 *Fire and Explosive Hazards* — same as for benzene (*see* **3** and **4.1.2**).

4.3 Xylene

4.3.1 *Health Hazards* — Xylene is not a highly toxic chemical but under certain conditions, it may be hazardous. The threshold limit value of xylene in air is established at 100 ppm by volume at the present time, but slight discomfort may be felt by some people at 50 ppm levels.

4.3.1.1 *Acute toxicity*

a) *Systemic effects* — In acute poisoning, xylene acts predominantly upon the central nervous system as a depressant causing fatigue, headache, confusion, paresthesia, dizziness and muscular incoordination. There is usually some delay in the development of symptoms and hence the effects commonly appear at the end of work shift.

b) *Local effects* — Contact of skin with liquid xylene produces sometimes a temporary burning sensation. Contact of the eyes with liquid xylene may cause severe irritation. Irritation of eyes, mucous membrane, and upper respiratory tract may occur with some individuals even at low concentration.

4.3.1.2 *Chronic toxicity*

a) *Systemic effects* — In chronic poisoning, commercial xylene may damage the blood and blood forming organs, if sufficient benzene is present.

b) *Local effects* — Frequent contact with xylene may cause defatting of skin and ultimately may lead to secondary infection.

4.3.2 *Fire and Explosion Hazards* — same as for benzene (*see* **3** and **4.1.2**)

5. HANDLING AND STORAGE

5.0 General — In all operations of transportation and storage of benzene, toluene and xylene, rules prescribed in the Petroleum Act or any other Act of Government of India shall be followed.

5.1 Handling

5.1.1 All precautions shall be taken to guard against health and fire hazards wherever benzene, toluene and xylene are handled.

5.1.2 Spark-resistant tools should always be used. If ferrous tools have to be used, they should always be kept wet with water. Any type of heating equipment which may generate flame or spark, shall not be permitted within the area where benzene, toluene and xylene are stored or used in large quantities. No body shall be permitted to smoke or to carry matches within the area. In order to prevent accumulation of static charges, the whole framework, the vessels and the pipe lines should be so grounded with heavy copper wires as not to have a resistance to ground greater than 5 ohms at a number of points. All electrical equipment including motors, lights, switches and wiring in areas where benzene, toluene and xylene are handled should be explosion-proof.

5.1.3 Use of air pressure for removing benzene, toluene and xylene through piping is extremely hazardous and shall not be permitted. Use an approved pump or an inert gas, such as nitrogen for pressure transfer.

5.1.4 Inspect pipes and equipment at regular intervals and stop even minor leaks as soon as they occur. If leaks or spills occur, only properly-protected personnel should remain in the area. Leaking containers should be removed to the outdoors or to an isolated, well-ventilated place and the contents should be transferred to other containers. All spills should be flushed away promptly with water.

5.1.5 In the laboratories where the testing procedures necessitate use of naked flame, the workers shall be well-conversant with the hazardous nature of these materials and the methods of controlling the hazards. All such work which requires heating shall be conducted on trays containing sand. Samples in small quantities only shall be taken to the laboratory and soon after the tests are over, the samples shall be removed from the laboratory.

5.2 Storage

5.2.1 The storage area should be kept clean. Oily rags, cotton waste, and straw should be removed from the storage area. Grass around this area should be cut short.

5.2.2 No material liable to spontaneous combustion, acids or oxidizing materials should be stored nearby.

5.2.3 When filled drums or other containers are stored indoors, they should be stored in non-combustible well-ventilated structures in accordance with the rules framed under Petroleum Act and other relevant Acts.

5.2.4 All storage areas should be isolated from all sources of open flame and well posted with ' NO SMOKING ' signs and provided with adequate fire-extinguishing system.

5.2.5 All storage tanks should have a vent pipe or sufficient area to permit the escape of air or vapours during filling operation. Flame arrestors should be fixed at the end of the vent pipe. The vents should terminate outdoor above roof level to prevent contamination of work-room air.

6. PACKING AND LABELLING

6.1 All containers should be securely packed and sealed.

6.2 All containers of benzene, toluene and xylene shall bear the label given in Fig. 3 of IS : 1260-1958*. The lower half of the label shall have the following words printed in red letters. Any other labels or warnings or other statements required by statutes, regulations or ordinances may also be used in combination or separately.

BENZENE/TOLUENE/XYLENE

Warning : **HIGHLY FLAMMABLE**

VAPOUR HARMFUL
KEEP AWAY FROM HEAT, SPARKS AND OPEN FLAME
KEEP CONTAINER CLOSED
USE ONLY WITH ADEQUATE VENTILATION
AVOID PROLONGED BREATHING OF VAPOUR

7. PREVENTIVE MEASURES

7.1 General — The precautions given in **7.1.1** and **7.1.2** should be taken routinely to avoid accident. They shall be observed even if the vapours of benzene, toluene or xylene are mixed with some other vapours.

7.1.1 No person should walk in storage and handling area with iron-studded shoes.

7.1.2 Air line masks shall be used in areas where benzene, toluene or xylene is leaking or has spilt.

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*Code of symbols for labelling of dangerous goods.

7.2 Employee Education and Training

7.2.1 Safety in handling benzene, toluene and xylene depends, to a great extent, upon the effectiveness of employee education, proper safety instructions, intelligent supervision and the use of safe equipment.

7.2.2 The education and training of employees to work safely and to use the personal protective equipment or other safeguards provided for them is the responsibility of supervision. Training classes for both the new and old employees should be conducted periodically to maintain a high degree of safety in handling procedures. Workers should be thoroughly informed of the hazards that may result from improper handling of benzene, toluene and xylene. They should be cautioned to prevent spills and thoroughly instructed regarding proper action to take in case they occur. Each employee should know what to do in an emergency and should be fully informed as to the first aid measures.

7.2.3 In addition to the above, employee education and training should include the following:

a) Instruction and periodic drill regarding the locations, purpose, and use of emergency fire fighting equipment, fire alarms, emergency shutdown equipment, such as valves and switches and personal protective equipment.

b) Instruction and periodic drill regarding the locations of safety showers, eye baths, and bubbler drinking fountains, or of the closest source of water for use in emergencies.

c) Instructions to avoid all unnecessary inhalation of vapours and all direct contact with the liquid.

d) Instructions to report to the proper authority all equipment failures and or signs of illness of employees exposed to benzene, toluene or xylene.

7.3 Personal Protective Equipment

7.3.1 *Availability and Use*

7.3.1.1 While personal protective equipment is not an adequate substitute for good and safe working conditions, adequate ventilation, and intelligent conduct on the part of employees working with benzene, toluene or xylene, it is, in many instances, the only practical means of protecting the worker, particularly in emergency situations. One should keep firmly in mind that personal protective equipment protects only the worker wearing it, and other unprotected workers in the area may be exposed to danger.

7.3.1.2 The correct usage of personal protective equipment requires the education of the worker in proper employment of the equipment available to him. Under conditions which are sufficiently hazardous to require personal protective equipment, its use should be supervised and the type of protective equipment selected should be capable of control over any potential hazard.

7.3.2 *Eye Protection*

7.3.2.1 *Chemical safety goggles* — Cup-type or rubber-framed goggles, equipped with the approved impact-resistant glass or plastic lenses, should be worn whenever there is danger of benzene, toluene or xylene coming in contact with the eyes. Goggles should be fitted by adjusting the nose piece and head band to ensure maximum protection and comfort.

7.3.2.2 *Spectacle-type safety goggles* — Metal- or plastic-rim safety spectacles with unperforated side shields which may be obtained with prescription safety lenses or suitable all plastic safety goggles may be used where continuous eye protection is desirable, as in laboratories. These types, however, should not be used where complete eye protection against benzene, toluene or xylene is needed.

7.3.2.3 *Face shields* — Plastic shields (full length, 20 cm *Min*) with forehead protection may be worn in addition to chemical safety goggles where complete face protection is desirable. Chemical safety goggles should always be worn as added protection where there is danger of material striking the eyes from underneath or around the sides of the face shield.

7.3.3 *Respiratory Protection*

7.3.3.1 Severe exposure to benzene, toluene or xylene may occur in tanks during equipment cleaning and repairs, when decontaminating areas following spills, or in case of failure of piping or equipment. Employees who may be subject to such exposures should be provided with proper respiratory protection and trained in its use and care. Available types are described below briefly (*see* Note 1) :

a) *Self-contained breathing apparatus* which permits the wearer to carry a supply of oxygen or air compressed in the cylinder, and the self-generating type which produces oxygen chemically, allow considerable mobility. The length of time a self-contained breathing apparatus provides protection varies according to the amount of air, oxygen or regenerating material carried. Compressed oxygen should not be used where there is danger of contact with flammable liquids, vapours, or sources of ignition, especially in confined spaces, such as tanks or pits.

b) *Positive pressure hose masks* supplied by blowers require no internal lubrication. The wearer shall be able to use the same route for exit as for entrance and shall take precautions to keep the hose line free of entanglement. The air blower shall be placed in an area free of contaminants.

c) *Air-line masks* supplied with clean compressed air are suitable for use only where conditions will permit safe escape in case of failure of the compressed air supply. These masks are usually supplied with air piped to the area from a compressor. It is extremely important that the air supply is taken from a safe source, and that it is not contaminated by oil decomposition from inadequate cooling at the compressor. The safer method is to use a separate compressor of the type not requiring internal lubrication. Pressure-reducing and relief valves, as well as suitable traps and filters, shall be installed at all mask stations.

d) *Industrial canister type gas masks* equipped with full-face pieces and fitted with the proper canister for absorbing vapours, will afford protection against concentrations not exceeding 2 percent by volume when used in accordance with the manufacturer's instructions. The oxygen content of the air shall not be less than 16 percent by volume. The masks should be used for relatively short exposure periods only. They may not be suitable for use in an emergency since, at that time, the actual vapour concentration is unknown and an oxygen deficiency may exist. The wearer shall be warned to leave the contaminated area immediately on detecting the odour of harmful vapour. This may indicate that the mask is not functioning properly, that the vapour concentration is too high, that the canister is exhausted, or that the mask is not properly fitted (*see* Note 2).

e) *Chemical cartridge respirators* may be used to avoid inhaling disagreeable but relatively harmless concentrations of benzene, toluene or xylene. These respirators, however, are not recommended for protection where toxic quantities may be encountered.

NOTE 1 — Respiratory protective equipment shall be carefully maintained, inspected, cleaned and sterilized at regular intervals, and always before and after use by another person.

NOTE 2 — Where carbon monoxide or other gas having little or no odour may be encountered in addition to benzene, toluene or xylene, the mask should be equipped with an ' all-purpose canister '.

7.3.4 *Head Protection*

7.3.4.1 ' Hard ' hats should be worn where there is danger from falling objects. If hard hats are not considered necessary, softbrimmed hats or caps may be worn to give protection against liquid leaks and splashes.

7.3.5 *Foot Protection*

7.3.5.1 Leather safety shoes with built-in steel toe caps are recommended for workers handling drums and cans of benzene, toluene or xylene. The leather should be coated with a shoe-coating compound impervious to hydrocarbon aromatic solvents. Overshoes made of synthetic rubber or other materials impervious to hydrocarbon aromatic solvents may be worn over leather safety shoes. Overshoes and shoes should be thoroughly cleaned and ventilated after contamination.

7.3.6 *Body, Skin and Hand Protection*

7.3.6.1 Sustained or intermittent skin contact with liquid benzene, toluene or xylene may produce dermatitis at the site of contact. It is imperative that contaminated clothing be removed promptly and laundered before re-use. Affected areas of the body should be washed thoroughly with soap and water to prevent possibility of absorption of benzene, toluene or xylene. Eyes should be flushed with copious amounts of water. As a general hygienic measure, facilities for personal cleanliness should be provided and washing before lunch and at the end of the work day should be encouraged.

7.3.6.2 Clothing made and coated with plastics or other impervious material may be worn to protect the body against benzene, toluene or xylene splashes. These garments shall be cleaned inside and out each time they are used.

7.4 Personal Hygiene

7.4.1 Employees should be instructed to have minimum contact with liquid or vapours of benzene, toluene and xylene. In any case, continuous exposure to concentration of these hydrocarbons above their threshold limit value should be avoided. Where unavoidable, proper respirators should be used.

7.5 Physical Examination

7.5.1 *Preplacement Examinations* — Most employees who can pass the usual preplacement physical examination (including a blood count) may be assigned to operations in which benzene, toluene or xylene is used. However, in order to protect the health of the individual, the examining physician may want to exclude people who present evidence or history of simple anemia or other blood cell diseases.

7.5.2 *Periodic Health Examinations* — Periodic examinations should be made at least once in 6 months of employees exposed to benzene and this should include systematic blood examination and urine sulphate test. In case of persons exposed to toluene and xylene vapours which contain an appreciable quantity of benzene associated with them, the symptoms of poisoning may be the same and they should be regularly medically checked up.

7.5.2.1 It is advisable that the workers who have been exposed to aromatic vapours for considerable length of time and have developed symptoms of poisoning should be transferred to other less dangerous units.

8. AIR ANALYSIS

8.0 General — Specially-calibrated combustible gas indicators are available where the concentration of benzene, toluene and xylene may be read from the meter directly. Ampoules changing colour on exposure to these hydrocarbons are also being marketed. Details of two chemical methods of benzene vapour measurements are given in **8.1** and **8.2**.

8.1 Meta Dinitrobenzene Method — This method is applicable in presence of toluene vapours.

8.1.1 *Reagents*

8.1.1.1 *Nitrating mixture* — Equal parts by volume of fuming nitric acid (density 1·50) and concentrated sulphuric acid (density 1·84).

8.1.1.2 *Sodium hydroxide solution* — Dissolve 400 g of sodium hydroxide and make up to 1 000 ml with distilled water.

8.1.1.3 *Sodium nitrate-sodium sulphate solution* — Dissolve 1·70 g of sodium nitrate and 0·86 g of anhydrous sodium sulphate in 100 ml water.

8.1.1.4 *Butanone (methyl ethyl ketone)* — Commercial grade, with a boiling range of 78·5 to 90·7°C, corrected to 760 mm mercury pressure (95 percent distilling at 81·9°C). The butanone may be used over again by separating it from the caustic layer shaking with calcium chloride to remove water and distilling over tartaric acid.

8.1.1.5 *Standard m-dinitrobenzene solution* — Dissolve 53·8 mg of *m*-dinitrobenzene (reagent quality, melting point 89·0 to 89·5°C) in 50-ml of nitrating mixture. Pipette 10 ml of this solution into a 100-ml volumetric flask and make up to volume with nitrating mixture. One millilitre of this solution is equivalent to 0·05 mg of benzene. The solution is stable for 6 months.

8.1.2 *Apparatus*

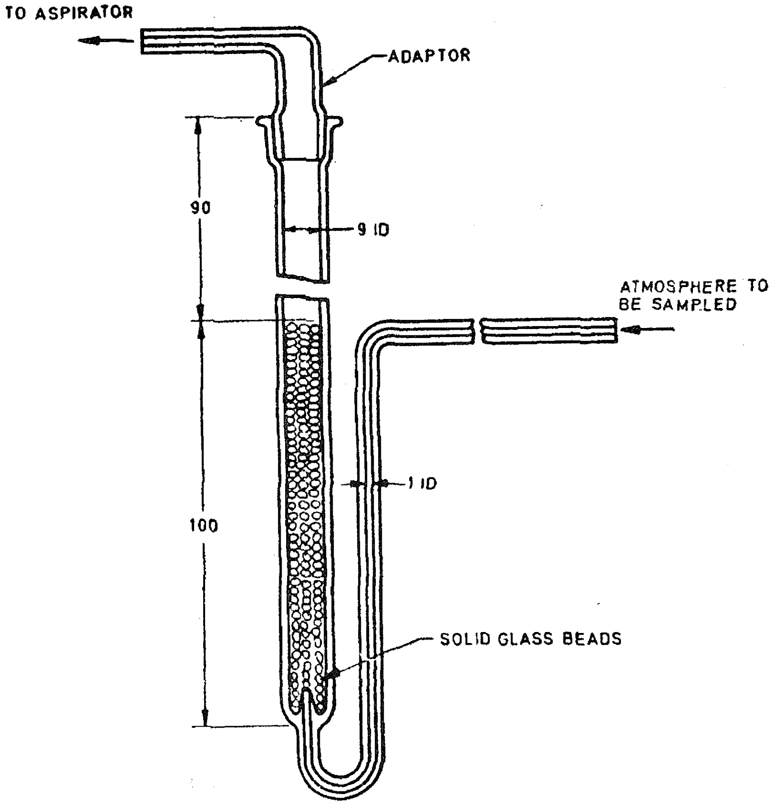
8.1.2.1 *Bubbler* — A small U-shaped tube with one wide arm and the other capillary arm filled with glass beads (*see* Fig. 1).

8.1.2.2 *Aspirator* — Calibrated to give volumes at different depths.

8.1.2.3 *100-ml Nessler tubes*

8.1.3 *Procedure* — Fill the wide arm of the bubbler with glass beads and pour slowly from the top about 2 ml of nitrating mixture. Connect the bubbler to a calibrated aspirator which is filled either with water or with mercury. Draw air to be tested through the bubbler by displacement at the rate of 20 to 30 ml/min. Normally 250 to 500 ml will be required for one determination.

8.1.3.1 Transfer the nitrating mixture and beads to a 100-ml glass-stoppered flask, and wash the bubbler with five 1-ml portions of distilled water which are also added to the flask. Neutralize the acid solution in a



All dimensions in millimetres.

FIG. 1 ABSORBER FOR THE DETERMINATION OF BENZENE VAPOUR IN AIR

cold water-bath (0 to 20°C) by titrating slowly with 40 percent sodium hydroxide, using litmus paper as an indicator, 1 to 2 drops being added in excess. Transfer the neutralized solution to a separatory funnel.

8.1.3.2 Add 10 ml of butanone to the solution and shake occasionally over a period of 10 minutes. It is important at this stage that the flask and contents be kept warm (about 25 to 30°C) to prevent salts from crystallizing, and thus interfering with quantitative separation of the butanone layer. Transfer the butanone layer to one of a series of comparator tubes of equal diameter (100-ml Nessler tubes are suitable for this purpose). Add 1·5 ml of a 40-percent aqueous sodium hydroxide solution to the butanone. Shake the tube vigorously for several minutes and occasionally during 60 to 90 minutes allowed for the colour to develop.

8.1.3.3 Prepare standards corresponding to 0·01 to 0·06 mg of benzene at intervals of 0·01 mg by carefully pipetting the required amount of the standard solution into glass-stoppered flasks. Make up the total volume of the solution to 2 ml with nitrating acid, to duplicate conditions in the unknown sample. Add 5 ml of distilled water. The remainder of the procedure for preparing the standards is the same as that described for the analysis of the samples.

NOTE 1 — It is essential that there shall be no contact with grease, wax, rubber, etc.

NOTE 2 — When the nitrating acid is neutralized, it is essential to add a drop or two of sodium hydroxide in excess, because if the solution is even slightly acid, a yellow colour develops when the sodium hydroxide is added to the butanone extract, which changes the quality of the colour produced by the *m*-dinitrobenzene and interferes with the determination.

NOTE 3 — The colours tend to fade slightly in artificial light but more rapidly in the daylight. It is advisable to keep the tubes out of the daylight while the colour is developing.

8.2 Formaldehyde-Sulphuric Acid Method — This method estimates benzene where toluene and xylene vapours are not expected since the reagent produces a colour readily with the latter.

8.2.1 *Reagents*

8.2.1.1 *Test solution* — 0·5 ml of 40 percent formaldehyde is measured out into the bubbler and 10 ml of sulphuric acid (sp gr 1·84) is stirred in.

8.2.1.2 *Standard* — 10 ml of a solution of sodium nitroprusside, made by dissolving 1 g in distilled water made up to 100 ml, is measured into a tube of the same diameter as the bubbler. This colour is equivalent to the colour of 10 ml of reagent which has reacted with one volume of benzene.

8.2.2 *Procedure* — Connect the bubbler with the pump and draw the air through (1 stroke/10 s) until the solution in the bubbler has the same colour as the standard. Note the number of strokes of the pump required.

8.2.3 *Expression of Result* — Calculate the volumes of air corresponding to the number of strokes of the pump from Table 2 and since this contains one volume of benzene vapour, calculate concentration of benzene in parts per million by volume.

NOTE — Thiophene and unsaturated hydrocarbons interfere with the test.

9. FIRST-AID

9.0 General — Immediate removal of the employee from exposure is the first thing to do. Contaminated clothing should be removed from body.

TABLE 2 DATA FOR BENZENE DETERMINATION

(*Clause* 8.2.3)

VOLUMES, AIR	NO. OF PUMP'S STROKES
700 to 1 200	1 to 2
1 200 „ 1 500	2
1 500 „ 2 000	3
2 000 „ 2 500	4
2 500 „ 3 000	5
3 000 „ 3 600	6
3 600 „ 4 200	7
4 200 „ 4 700	8
4 700 „ 5 300	9
5 300 „ 6 000	10
7 000	12
8 000	15
10 000	18

9.1 Contact with Eyes

9.1.1 If liquid benzene, toluene or xylene enters the eyes, flush thoroughly with plenty of water for 15 minutes. If irritation persists, medical attention should be obtained.

9.2 Ingestion

9.2.1 There is no specific antidote for benzene, toluene or xylene poisoning. If patient is conscious, make him vomit by giving warm salt water (2 teaspoonfuls in a glass of water). If patient does not vomit spontaneously, stimulate vomiting by sticking finger down throat. Call a physician. Keep patient warm and quiet until physician arrives. Never give anything by mouth to an unconscious person.

9.3 Inhalation

9.3.1 In case of unusual exposure to high concentrations of benzene, toluene or xylene vapours, call a physician immediately. Immediately remove the patient to fresh air. To prevent collapse, the patient should lie down without a pillow and be kept quiet and warm. If he is so violent that restraint is necessary, take care that in tying arms and legs, there is no interference with circulation and respiration.

9.3.2 If the patient is unconscious, lay the patient down, preferably on the left side with the head low. Remove any false teeth, chewing gum, tobacco, or other foreign objects which may be in the mouth.

9.3.3 If the patient is not breathing, an effective means of artificial respiration should be started at once.

9.3.4 If oxygen inhalation apparatus is available, oxygen should be administered but only by a person authorised for such duty by a physician.

10. TANK CLEANING AND REPAIRS

10.1 Tank and equipment cleaning should be done under the direction of thoroughly-trained personnel who are fully familiar with all of the hazards and the safeguards necessary for the safe performance of the work.

10.2 Tanks and equipment, pumps, lines and valves should always be drained and thoroughly flushed with water before being repaired. Workmen should never be allowed to attempt to repair equipment while it is in operation and the lines full. If pipe sections are to be removed and flanges opened, the lower bolts should be loosened first and although the lines have been flushed, care should be taken to avoid personal contact with the liquid draining or dripping from the equipment. All spillage from the lines or equipment should be removed immediately by flushing to the drain with large quantities of water.

10.3 The tank or equipment to be repaired should first be emptied of all liquid, and all pipes leading to and from the tank (except vents) after draining should be disconnected or blanked off.

10.4 The tank should be steamed to remove residual hydrocarbons and vapours. Steam lines should be large enough to raise the tank temperature above the boiling point of benzene, toluene or xylene and the steaming should be continued until the benzene, toluene or xylene vapours have been removed.

10.5 The tank should be cooled, preferably by filling with water and draining once or twice. The tank should then be purged with fresh air and the air should be tested for hydrocarbon vapour by an approved method before permitting personnel to enter.

NOTE — The volatilized hydrocarbon in the steam effluent should not be of sufficient concentration to contaminate the work area in excess of safe limits.

10.6 One man on the outside of the tank should keep the man in the tank under observation and another man should be available nearby to aid in rescue if any of the men in the tank are overcome.

10.7 A supplied-air respirator or self-contained breathing apparatus, together with rescue hearness and life line should always be located outside the tank entrance for rescue purposes, regardless of the type of respiratory equipment or air supply which is provided for employees inside the tank. Special ventilation is recommended during the entire time men are cleaning, repairing, or inspecting the tank.

10.8 During the course of the work, frequent tests should be made to determine that the atmosphere in the tank is being maintained within the safe range. This precaution is necessary because residues not completely removed by washing may recontaminate the tank atmosphere.

10.9 Emergency Rescue — Under no circumstances should a rescuer enter a tank to remove a victim of overexposure without proper respiratory protection, a safety harness and an attached life line. The free end of the life line should be manned by an attendant located outside the tank. Another attendant should be immediately available to assist in the rescue if needed. The rescuer should be in view of the outside attendant at all times or in constant communication with him.

10.10 Exterior Repair Work — Exterior tank repairs, including repairs to steam coils, cutting, riveting and welding, should be permitted only after thorough cleaning and testing of the tank to make sure that it is free of vapours and after a work permit has been issued by an authorized person. Repeated tests with an approved combustible gas indicator should be made to fully protect the workmen.

10.10.1 All outside welding or burning on tanks or equipment which have contained benzene, toluene or xylene should be done only after such containers have been completely purged with steam. Purging should be continued while the repair work is in progress. Filling clean, empty tanks with inert gas is another method which may be used in outside welding or burning.

11. WASTE DISPOSAL

11.1 The disposal of benzene, toluene or xylene should take cognizance of the rules framed by duly constituted authorities.

11.2 Disposal of small quantities may be accomplished by removal of the waste to a safe location away from the buildings or other combustible structures, then pouring the mixture on dry sand or earth and cautiously igniting it. Flammable materials, such as straw cotton waste, and saw dust soaked with benzene should also be similarly disposed.

11.3 Waste mixtures should not be allowed to enter drains or sewers where there is the danger of the vapours being ignited.

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